

# PRODUCER'S GUIDE FOR ITEM SPECIAL - HAMCIN: CLSM-CDF

## INTRODUCTION

This producer's guide is published as a supplement to the newly adopted Hamilton County's and the City of Cincinnati's performance specification for trench backfilling consisting of the use of Controlled Low Strength Material - Controlled Density Fill. Hereafter referenced by the acronym: CLSM-CDF. There are a number of producer trade names for CLSM-CDF: K-Krete®, M-Crete, Darafill™, Flash Fill®, Flowable Fill, Flowable Mortar, Unshrinkable Fill, etc. The purpose of this guide is to provide CLSM-CDF producers with technical and procedural information for meeting the requirements of the performance specification. Producer is being defined as the manufacturer and supplier of the CLSM-CDF mixture. To help the reader compare this guide to the performance specification, the same section titles and section numbers have been used.

### 1.0 DESCRIPTION

While there are many engineering applications for the use of Controlled Low Strength Materials, this performance specification consists of the placement of flowable backfill mixtures which are covered, as previously referenced, by the acronym: CLSM-CDF. These mixtures must contain the following properties: flowability (ASTM PS 28) for placement, support strength (ASTM D 4832) for traffic loads, and removability, after placement. The material's strength and removability requirements are discussed in the next section. The material may be produced off-site or on-site. In either case, the producer of the material must meet certification requirements as outlined in Section 2.0 PRODUCER CERTIFICATION of performance specification.

### 2.0 PRODUCER AND MATERIAL CERTIFICATION

CLSM-CDF producer certification is included in the performance specification as a way to maintain quality control of the material during all phases of its production and field placement. Prior to a producer's initial manufacturing and furnishing of any CLSM-CDF mixture, the material producer must comply with the following:

2.1 Demonstrate its ability for the production of a uniform CLSM-CDF mixture meeting all engineering properties. Current National Ready Mix Concrete Association's (NRMCA) plant and truck certification will satisfy this requirement for the producer. The producer should submit a copy of NRMCA's plant and truck certification certificate. This information should be submitted using *HAMCIN Producer Certification Form* with pertinent data.

2.2 For the proposed CLSM-CDF mixture the following engineering data must be submitted:

2.2.1 Thirty (30) and (90) day unconfined compressive strength (C') (ASTM D 4832). For early paving requirements, within 2 hours, the minimum load bearing strength shall be 20 psi. If early loading is not required, there is no 2 hour strength requirement.

2.2.2 Yield and dry unit weight (ASTM PS 29).

2.2.3 Flowability (ASTM PS 28).

Previous test results, on mixtures using the same mixture components, will satisfy this requirement.

2.2.4 Removability: The dry unit weight (w) in conjunction with the thirty (30) day compressive strength (C') are used to determine the material's removability (diggability or excavatability). Material will be considered removable if the Removability Modulus (RE), as determined by the following equation is equal to 1.0 or less.

$$RE = \frac{w^{1.5} \times 104 \times C'^{0.5}}{10^6} = < 1.0 \quad \text{Equation (1)}$$

where:

w = dry unit weight (hardened material) (pcf)

C' = thirty day unconfined compressive strength (psi)

2.2.5 Mixture's components (cement, water, fly ash, filler aggregate etc.) and sources (company and location): This information is very important for quality control. Changes in any source require recertification of the mixture. The producer should be aware that changes in portland cement and other sources can change the compressive strength of the mixture.

This engineering data should be submitted using HAMCIN's *Engineering Data Report Form* with pertinent laboratory test data. Table 1 shows Removability Modulus (RE) values for various combinations of compressive strengths (C') and unit weights (w) as determined by Equation (1). If it is determined, for the engineering data presented: flowability, adequate strength, and removability requirements are not acceptable, the use of this mixture will not be allowed. Meeting these certification regulations does not relieve the producer of the material liability referenced in Section 7.0 of the performance specification.

### 3.0 MATERIALS

The performance specification places the responsibility for the various material components, for a CLSM-CDF mixture, on the producer. All mixture components must be environmentally acceptable. A Material Safety Data Sheet (MSDS) for each mixture's component must be available upon request.

It is important to understand that the CLSM-CDF mixture must be able to flow into the excavation, thereby significantly reducing labor requirements for placing. Tests have been developed for the determination of adequate flowability. "Field Testing For Flowability" (ASTM PS 28) is such a test. An average flow diameter of approximately 8" is considered adequate for good flowability.

TABLE 1 - REMOVABILITY MODULUS (RE)								
w (pcf)	Compressive Strength (C') (psi)							
	25	50	75	100	125	150	175	200
50	0.18	0.26	0.32	0.37	0.41	0.45	0.49	0.52
70	0.30	0.43	0.53	0.61	0.68	0.75	0.81	0.86
90	0.44	0.63	0.77	0.89	0.99	1.09	1.17	1.26
110	0.66	0.85	1.04	1.20	1.34	1.47	1.59	1.70
130	0.77	1.09	1.33	1.54	1.72	1.89	2.04	2.18
150	0.96	1.35	1.65	1.91	2.14	2.34	2.53	2.70

Note: Hard clay's RE = 1.15 psi

Very stiff clay's RE = 1.00 psi

3000 psi portland cement concrete's RE = 10.26 psi

The values in the shaded area would not meet the material removability requirement.

CLSM mixtures offer an excellent opportunity for the use of recycled and non-standard materials for the filler aggregate. Recycled materials could consist of pavement materials and industrial byproducts. Non-standard materials consist of material not meeting ASTM C33. For example, a stone quarry may have a granular material that does not meet the gradation requirements for ASTM C33; this material could work in a CLSM mixture. The prime function of the filler aggregate is to occupy the major portion of a mixture and be compatible with the other mixture components. Prior to the use of recycled materials, laboratory testing should be conducted to assure end use results for: strength, removability, flowability, and compressibility. It has been observed, that recycled materials can drastically reduced the cost of CLSM mixtures.

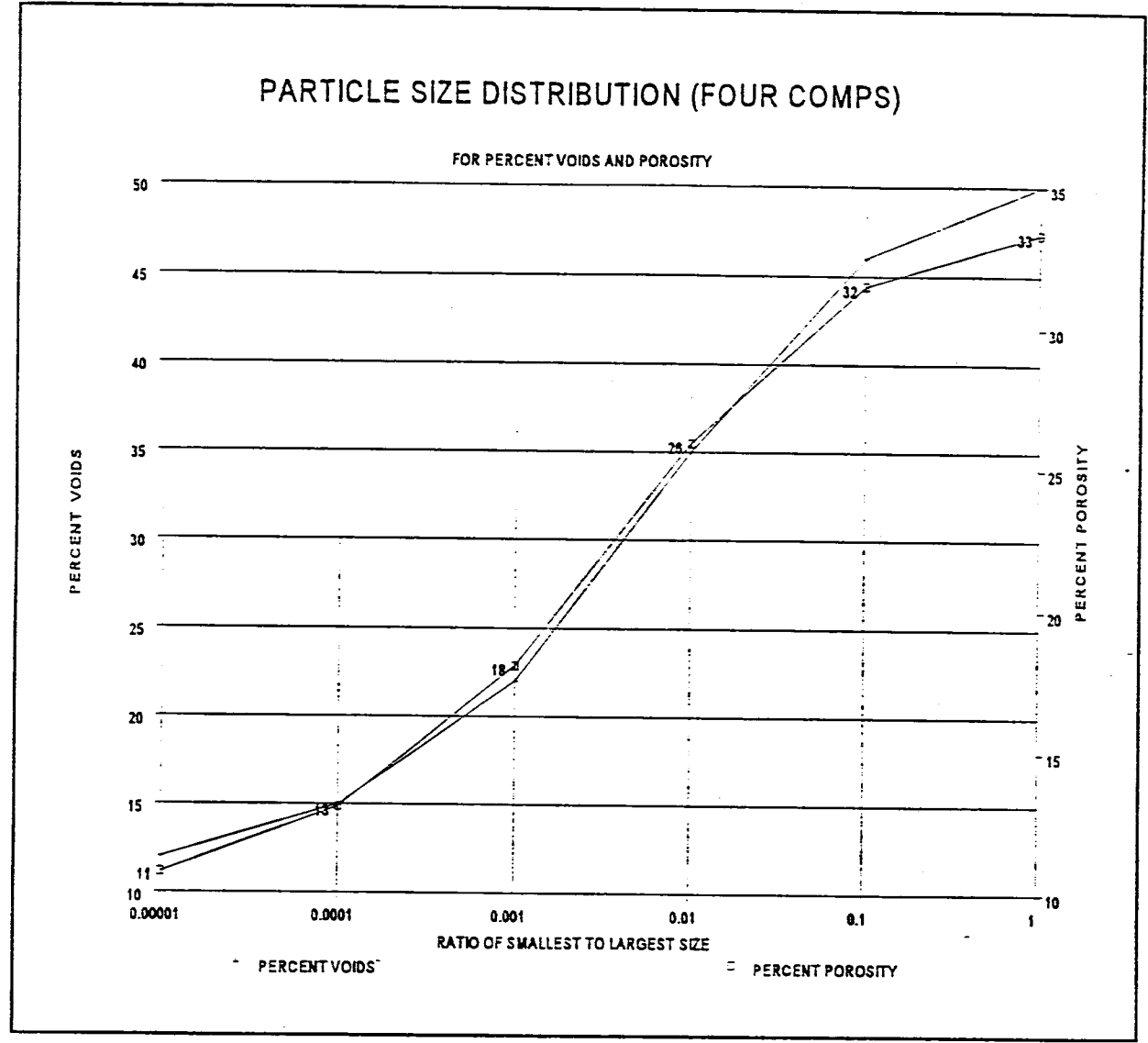
3.1 (Reserved for future use)

3.2 (Reserved for future use)

#### 4.0 MIXTURE PROPORTIONS

The mixture proportions, as with the mixture's components, are the responsibility of the producer. The produced mixture must meet the engineering requirements as specified in Section 2.2 of the performance specification: compressive strength, dry unit weight, flowability, and removability. Failure to meet, or sustain, a certified mixture's consistency for the stated engineering properties, will result in the rejection of the mixture.

The requirement for a permeability coefficient "k" of  $1 \times 10^{-5}$  cm/sec can be met in a number of ways. Some trade name CLSM-CDF material producers, using various admixtures, have addressed compliance to this requirement. For CLSM-CDF mixtures containing: cement, fly ash, and aggregate filler the requirement can be met by controlling the particle sizes of the mixture. The following figure shows the relationships between a material's percent voids, percent porosity,



and a ratio of the smallest to largest particle size.

To assist in designing CLSM-CDF mixtures, meeting the specified permeability see Table 2.

TABLE 2 - PERMEABILITY COEFFICIENT "k" ( $\times 10^{-5}$ )(cm/sec) (60° F.)

Eff. Size $D_{10}$ (mm)	Porosity (Percent)						
	24	26	28	30	32	34	36
0.01	-	0.4	1.0	1.5	2.0	2.4	3.0
0.02	0.6	2.8	4.8	6.5	8.2	10.0	12.0
0.03	4.0	8.2	11.8	15.2	18.6	22.4	26.7
0.04	5.4	13.4	20.4	26.9	33.3	40.3	48.2
0.05	6.5	19.1	30.9	41.5	51.9	62.9	75.4

where:

The Effective Size ( $D_{10}$ ) = 10% of the particles are smaller than the Effective Size ( $D_{10}$ ) and 90% consist of larger particles.

Porosity =  $e/(1+e)$ , where  $e$  = voids ratio.

## 7.0 ACCEPTANCE OF MATERIAL AND FIELD TEST REQUIREMENTS

The specification instructs the CLSM-CDF producer what steps must be taken to comply with the performance specification. The acceptance steps are reproduced here with additional reference information.

7.1 Producer certification (Section 2.1 of this specification.): The NRMCA plant and truck certification was selected because it contains quality control concerns for concrete that are similar to those for the production of a CLSM-CDF mixture.

7.2 Field testing for flowability (ASTM PS 28): This field or laboratory test provides a quick reference for a CLSM-CDF's flowability capabilities. A CLSM-CDF mixture, with a uniform eight (8") diameter spread, is considered to have good flowability.

7.3 Sampling freshly mixed CLSM (ASTM PS 30).

7.4 Cylinder (3" x 6") strengths (ASTM D 4832). Six (6) cylinders will be required for any placement of 100 cubic yards and each 100 cubic yards there after. Three (3) cylinders will be broken at 30 and 90 days. If the placement is less than 100 cubic yards, three (3) cylinders will be taken every fifty cubic yards of production. Two cylinders will be broken at 30 days and one (1) cylinder at 90 days. These cylinders tests are necessary to insure adequate load carrying capacity and removability of the mixture.

Once a producer has test data on specific CLSM-CDF mixtures, that test can be used to meet the specification requirement for Producer Certification, engineering data, part 2.2. Therefore, it is important to retain strength and material records, as noted in the specifications, for CLSM-CDF mixtures.

- 7.5 Unit weight tests (ASTM PS 29) will be made when cylinders are made. The recorded unit weight will be adjusted to the hardened unit weight. This unit weight is the unit weight to be used in Equation 1 for determining Removability Modulus (RE). As a check on this unit weight, the weight of the cylinder, prior testing will also be taken. All tests are to be performed by an by qualified testing personnel. The minimum acceptable requirement is ACI Level I, Concrete technician.

## INTRODUCTION

This contractor's guide is published as a supplement to the newly adopted Hamilton County's and the City of Cincinnati's performance specification for trench backfilling consisting of the use of Controlled Low Strength Material - Controlled Density Fill. Hereafter referenced by the acronym: CLSM-CDF. The specification is defining the *contractor* as the purchaser and user of CLSM-CDF mixtures and the *producer* as the manufacturer and supplier of the CLSM-CDF mixture. The contractor should be aware that there are a number of producer trade names for a CLSM-CDF mixture: K-Krete®, M-Crete, Darafill™, Flash Fill®, Flowable Fill, Flowable Mortar, Unshrinkable Fill, etc. The purpose of this guide is to provide contractors with technical and procedural information for meeting the requirements of the performance specification. To help the reader compare this guide to the adopted CLSM-CDF performance specification, the same section titles and section numbers have been used.

### 1.0 DESCRIPTION

While there are many engineering applications for the use of Controlled Low Strength Material, this performance specification consists of the placement of flowable backfill mixtures which are covered, as previously referenced, by the acronym: CLSM-CDF. These mixtures are designed to possess specific engineering properties: flowability for placement, support strength for traffic loads, and removability, after placement. Prior to the use of any CLSM-CDF mixture, the producer and the proposed mixture must to be certified as outlined in Section 2.0 PRODUCER AND MATERIAL CERTIFICATION of the performance specification.

The contractor should be aware that this specification is a performance specification. The CLSM-CDF producer is totally responsible for designing a mixture to meet all the specified engineering requirements.

### 2.0 PRODUCER AND MATERIAL CERTIFICATION

CLSM-CDF producer and material certification has been included in the performance specification as a way to maintain quality control of the material during all phases of its production and field placement. The contractor shall not use a CLSM producer, or mixtures, that have not been certified as per the performance specification. A list of certified CLSM producers and mixtures are available from the Hamilton County and City of Cincinnati.

2.1 (Reserved for future use)

2.2 (Reserved for future use)

2.2.1 (Reserved for future use)

2.2.2 (Reserved for future use)

2.2.3 (Reserved for future use)

2.2.4 (Reserved for future use)

2.2.5 (Reserved for future use)

### 3.0 MATERIALS

The producer is responsible for the materials used in the production of a CLSM-CDF mixture. It is important to understand that the CLSM-CDF mixture must be able to flow into the excavation thereby eliminating all labor requirements for placing. Tests have been developed for the determination of adequate flowability. "Field Testing For Flowability" (ASTM PS 28) is such a test. A flow diameter of 8" is considered adequate flowability.

3.1 (Reserved for future use)

3.2 (Reserved for future use)

### 4.0 MIXTURE PROPORTIONS

The contractor has no direct responsibility for a mixture's proportions. The contractor however should be aware of the producer's responsibility in regard to the mixture's proportions. The produced mixture must meet the certification and engineering requirements as specified in Section 2.2 of the specification: compressive strength, dry unit weight, flowability, and removability. Failure to meet, or sustain, a certified mixture's consistency, for the stated engineering properties, will result in the rejection of the mixture.

### 5.0 PLACING (POURING)

The CLSM-CDF mixture can be placed directly into a trench or excavation. The mixture can also be pumped. In either case, the material's flow characteristic will be such that no labor will be required in the trench or excavation. This means that no vibration or compaction equipment shall be used. If the trench or excavation contains water, the CLSM-CDF mixtures may be used to displace the water provided that an adequate water runoff area is available. Depending on the size of the project, the producer may be required to pour the CLSM-CDF mixture in several locations. While properly designed CLSM-CDF has flowability qualities, there are limits in just how far the material can flow. Specific flow distances will depend on the mixture's design and aggregate filler material's particle shape.

## 6.0 CONSTRUCTION REQUIREMENTS

The primary use for CLSM-CDF is for trench and excavation backfills. In either case, some type of vertical barrier, such as the trench sidewall is required to contain the flowable material. For long trenches, requiring a large amount of CLSM-CDF material, bulkheads can be used to control the material's flowability. A bulkhead, consisting of soil, has to be removed prior to the continuation of backfilling. This is required to achieve backfill uniformity. Wooden and/or steel bulkheads can be used to control the mixture's flow. Sand bags can also be used for bulkheads. They can be easily placed, removed and reused.

The contractor needs to be aware of related construction requirements which include: trench width, OSHA, possible conduit flotation, and speed of backfill placement. Trench widths can be reduced with the use of CLSM-CDF since a wider trench is not required to achieve adequate compaction around the conduit. This trench reduction width also reduces excavation costs and the amount of backfill material required. Attention is called to the Occupational Safety and Health Administration (OSHA) regulations regarding trenches. This information is found in: 29 CFR, Ch. XVII, 1926.652. For conduit placement, with a "steel box" and CLSM-CDF backfilling, sloping sides can be eliminated since no personnel are required to be in the trench during backfilling. The use of CLSM-CDF substantially reduces the time required for backfilling. Backfilling is as fast as the CLSM-CDF material can be poured into the trench, provided that possible conduit flotation is controlled.

6.1 (Reserved for future use)

6.1.1 (Reserved for future use)

6.1.2 (Reserved for future use)

6.1.3 (Reserved for future use)

6.1.4 (Reserved for future use)

## 7.0 ACCEPTANCE OF MATERIAL AND FIELD TEST REQUIREMENTS

The CLSM-CDF producer is required to follow specific steps for material acceptance. For contractor reference, these steps are:

7.1 Producer certification (Section 2.1 of this specification.): The contractor should request list of certified producers from Hamilton County or City of Cincinnati.

7.2 Field testing for flowability (ASTM PS 28): This field or laboratory test provides a quick reference for a CLSM-CDF's flowability capabilities. A CLSM-CDF mixture, with a uniform eight (8") diameter spread, is considered to have good flowability. If the flow characteristics are poor, the contractor should reject the material.

### 7.3 Sampling freshly mixed CLSM (ASTM PS 30)

7.4 Cylinder (3" x 6") strengths (ASTM D 4832). Six (6) cylinders will be required for any placement of 100 cubic yards and each 100 cubic yards thereafter. Three (3) cylinders will be broken at 30 and 90 days. If the placement is less than 100 cubic yards, three (3) cylinders will be taken every fifty cubic yards of production. Two cylinders will be broken at 30 days and one (1) cylinder at 90 days. These cylinders tests are necessary to insure adequate load carrying capacity and removability of the mixture. The contractor should be aware that these cylinders are usually required as part of the quality control program for CLSM-CDF use. The Engineer may modify or change acceptance testing requirements.

7.5 Unit weight tests (ASTM PS 29) will be made when cylinders are made. All tests are to be performed by an approved county or city testing laboratory and by personnel having a minimum certification of ACI Level I, Concrete Technician. This requirement is included to insure the accuracy of test data.

## 8.0 METHOD OF MEASUREMENT

Measurement will be based on (cubic yards) will be based on computed plan quantities. No additional compensation will be allowed for over excavation. The hardened volume of the CLSM-CDF mixture will be less than the plastic state. The volume change is primarily a function of the water lost in subsidence (compaction and hardened) of the material. This exact amount will be known from unit weight tests and this information will be available to contractors for bidding purposes. A contractor should determine the volume (cubic yards) required. The CLSM-CDF producer will supply enough material, in the plastic state, to fill the measured volume.

## 9.0 BASIS OF PAYMENT

Payment will be based on the cubic yards for the computed plan quantities.

## 5.0 PLACING (POURING)

The CLSM-CDF mixture can be placed directly into a trench or excavation. The mixture can also be pumped. In either case the material's flow characteristic will be such that no labor will be required in the trench or excavation. This means that no vibration or compaction equipment shall be used. If the trench or excavation contains water, the CLSM-CDF mixtures may be used to displace the water provided that an adequate water runoff area is available. Depending on the size of the project, the producer may be required to pour the CLSM-CDF mixture in several locations. While properly designed CLSM-CDF has flowability qualities, there are limits in just how far the material can flow. Specific flow distances will depend on the mixture's design and aggregate filler material's particle shape.

## 6.0 CONSTRUCTION REQUIREMENTS

Construction requirements pertain more to the contractor than to the CLSM-CDF producer. While this producer's guide specifically deals with CLSM-CDF (backfill), the reader should be aware of other CLSM applications that require changes in the CLSM mixture. These other applications would consist of pavement bases, structural fills, and special engineered fills. The use of CLSM mixtures, for these applications, are not covered in the performance specification.

6.1 (Reserved for future use)

6.1.1 (Reserved for future use)

6.1.2 (Reserved for future use)

6.1.3 (Reserved for future use)

6.1.4 (Reserved for future use)

If the CLSM-CDF mixture is produced and transported in ready mixed concrete trucks, load capacity of the mixers may have to be reduced due to the high fluidity of the mixture. To compensate for this condition, the producer may consider the following:

- Cut back on water and add additional water at site.
- For rear discharge mixers, use an end plug.
- Use front end discharge mixers.

The producer should be aware of limitations of operations as described in this section of the specification.